

**OBSERVATIONS ON THE BIOLOGY OF *ARHOPALA WILDEI* MISKIN (LEPIDOPTERA: LYCAENIDAE) AND ITS HOST ANT *POLYRHACHIS QUEENSLANDICA* EMERY (HYMENOPTERA: FORMICIDAE)**

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**Abstract**

Observations on the biology of *Arhopala wildei* Miskin and *Polyrhachis queenslandica* Emery are recorded, as well as details of their interactions. Ant assisted cuticle removal during ecdysis of *A. wildei* larvae is recorded for the first time, as well as pupal stridulation and pupal oscillation (vibration) in *A. wildei*.

**Introduction**

The myrmecophilous early stages of the lycaenid butterfly, *Arhopala wildei* Miskin, have been described recently by King and Ring (1996). The butterfly deposits its eggs near the nest entrance of the arboreal ant *Polyrhachis queenslandica* Emery and the first instar larvae are carried into the nest by the ants. The larvae then remain in the nest where they feed on the ants' brood. Additional behavioural observations reported in this paper were made independently by the present authors at the same location near Waughs Pocket, north of Innisfail and at other sites in northern Queensland.

**Observations**

**Adult butterfly behaviour**

Males of *A. wildei* are active in early morning sunshine (*c* >0600h EST), often flying close to the ground in clearings whilst "dogfighting" with other males. During the early part of the day males often search the foliage of vine forest trees, especially near *P. queenslandica* nests, possibly in search of freshly emerged females. They later retreat into the foliage and are seen only occasionally. Pairs *in copula* were observed on exposed foliage in mid-morning (*c* 0900h EST), adjacent to areas of male activity. When disturbed, mating pairs drift to a lower perch, seemingly unable to sustain flight. The mating ritual was not observed.

Females are seen most commonly investigating the foliage between mid-morning (0900h) and mid-afternoon (1500h) and have been observed depositing eggs between these times. Whilst searching for egg laying sites, females adopt a slow flight pattern with much fluttering in and around the foliage. On occasion, they will fly quickly out of the foliage with a short burst of fast circling flight – apparently after being disturbed. Some older females remain in the vicinity of *P. queenslandica* nests for extended periods (3-4 hrs), occasionally flying off and returning to rest nearby.

Adult butterflies were not seen to visit any flowers in the study area. However, they were seen in the company of other *Arhopala* Boisduval

species, *A. micale amphis* Waterhouse and *A. madytus* Fruhstorfer and other insects (wasps and ants), feeding on exudates at the leaf petiole junction of the large-leafed vine *Merremia peltata* (L.) Merr. (Convolvulaceae).

#### The ant nest

Nests of *P. queenslandica* ranged in size from very small ( $c 1 \text{ cm}^3$ ), containing just a Queen, sometimes with a few early stages, up to large nests ( $>100 \text{ cm}^3$ ) with more than 100 adult ants and a similar number of immature stages. Most nests were around  $30 \text{ cm}^3$  and contained 40-50 mature ants. A typical *P. queenslandica* nest is constructed of two, or sometimes three overlapping leaves sealed along the sides with what appears to be masticated bark. The inside of the nest has no compartments and all surfaces are covered by a thin layer of light brown silk. A dead pupa of *A. wildei* in one *P. queenslandica* nest was likewise webbed over. Two or three tube-like access holes of 3 mm diameter are built into the webbing at opposite ends of the nest. During the day, guard ants can be seen in these access holes.

*P. queenslandica* also nest opportunistically. One group nested in a cavity under a plastic table using nesting material removed from a damaged nest. In the wild they have been found nesting in an abandoned wasp nest (S. Robson, pers. comm.).

Nest sites for *P. queenslandica* varied in height from 30 cm above ground to high in the intermediate canopy in protected positions. Most of the nests were situated 3-5 m above the ground in the overhanging lower canopy of a forest boundary. This part of the canopy is protected from strong winds and is also where most of the *A. wildei* females were observed to fly. Ant nests may be up to 30 m above the ground as some *A. wildei* females were seen investigating foliage at this level. *P. queenslandica* nests were found on both windward and leeward sides of forest boundaries, in foliage with and without green tree ants *Oecophylla smaragdina* (Fabricius) and other *Polyrhachis* F. Smith species.

*P. queenslandica* nests are very clean inside. Remains of ant eggs, larvae and pupae after consumption by *A. wildei* larvae are ejected from the nest by the ants. Dead ants and *A. wildei* larval frass also are ejected. However, some nests contained a number of fluffy, white, papery objects of various sizes which proved to be the masticated exuviae of *A. wildei* larvae. No empty *A. wildei* pupal cases were found in an active nest and it would appear that the ants destroy or eject empty butterfly pupal shells.

#### Ant behaviour

When disturbed, *P. queenslandica* adopt a defensive threatening posture. They curl their gaster forward under the mesosoma, striking it repeatedly on the substrate for one to two seconds, producing an audible rattling or drumming sound. In daylight hours, the ants are reluctant to leave the nest, even when disturbed. If the nest is breached, workers will form a line, face



the exposed breach in the defensive posture and spray fluid from the gaster at any intruder. Observations made on a number of disturbed nests showed that nests suffering minor damage were quickly repaired the same night, while the majority of those that had sustained major damage were found abandoned the next day.

When two ant nests taken from about 50 m apart were placed in the same container, these nests merged into one with the expulsion of one queen and three worker attendants. The exiled queen was later killed by two other workers and the three attendants returned to the new single nest. On other occasions, ant brood from one nest was placed in a container housing another ant nest taken from a different location. The introduced ant brood was picked up by the other ants and placed inside the nest. *P. queenslandica* from different nests were not aggressive to one another as is the case with many other species of ants (Hölldobler and Wilson 1990). *A. wildei* larvae transferred from one nest to another were similarly accepted without hesitation.

#### Butterfly oviposition

*A. wildei* eggs are laid singly or in small groups of two to four on the ant nest material, usually near the tubular access holes. The host ants were not seen to attack females laying eggs. A small number of *P. queenslandica* nests, with and without *A. wildei* eggs attached, were found to be abandoned and one abandoned ant nest was found to contain an empty pupal shell of *A. wildei*. Nests without eggs attached were occasionally found to contain one or more semi-mature *A. wildei* larvae. More often there were fewer butterfly larvae in the ants' nest than hatched eggs on the outside. The majority of nests with butterfly eggs were around 20-30 cm<sup>3</sup> and had 3-5 eggs attached. Some of the large-leaved evergreen trees in which larger nests were found, hold their foliage for at least two years and it is possible that these nests have supported continuous generations of *A. wildei* over that period of time. Only one intact *A. wildei* egg was found with a hole cut in the side, indicating that egg parasitoids may be present.

#### *A. wildei* larvae in the ant nest

In similar fashion to another myrmecophage, *Acrodipsas illidgei* Waterhouse & Lyell (Samson 1989), freshly emerged first instar *A. wildei* larvae are carried into the nest by the ants and therein remain very difficult to detect. Eggshells are neither eaten by the freshly emerged larvae nor removed by the ants and oophagy was not observed. *A. wildei* larvae of less than 2 mm in length were seen clinging to the ants' silken pupal cases or attached to ant eggs in the brood batch. Ant eggs and larvae appear to be coated with a thin, viscid layer. This substance enables the ant eggs and larvae to adhere to each other and to the nest wall, and facilitates the movement of batches of brood by individual ants. Small *A. wildei* larvae also adhere to the ant brood and are likewise moved by the ants. In the event of a major disturbance the ants



pick up the ant brood, with lycaenid larva attached, and retreat to the darker corners of the nest. Ants will often pick up *A. wildei* larvae instead of their own brood.

The host ants do not show any aggressive behaviour towards any instar larvae of *A. wildei*. *A. wildei* larvae have been observed consuming *P. queenslandica* eggs and larvae and there is circumstantial evidence that they also eat ant pupae. Trophallactic feeding was not observed between the butterfly larvae and adult ants. However, it may occur since the ants seem to treat *A. wildei* larvae, in all other respects, like their own. Butterfly larvae are regularly attended by the ants with particular attention being paid to the Newcomer's organ (NO). Exudates from this organ collect in the concave anal depression of the *A. wildei* larva and often, when approached by an ant, the larva will raise its posterior end to a vertical position, facilitating direct access to the NO by the ant. Similar behaviour has been observed in *Acrodipsas illidgei* by Samson (1989). The queen ant also attends the NO of *A. wildei*.

#### *A. wildei* larval ecdysis

Two attendant *P. queenslandica* were observed to carefully remove the moulting cuticle from a second instar *A. wildei* larva. The action was performed at first with both ants pulling and then with one ant holding the larva in its mandibles, while the other ant slowly peeled back the loose exuvium. This was followed by a lengthy session of meticulous grooming with the larva being turned over several times, apparently under duress. The exuvium was then picked up by one of the attendant ants and thoroughly masticated before being dropped. It was not ejected from the nest. This entire process was performed by the same two ants without intervention from others nearby.

#### Pupal stridulation and oscillation (vibration)

*A. wildei* pupae stridulate but, unlike other lycaenids that stridulate with intermittent bursts of "ticks" or "burrs", they emit a prolonged "burr" that may last for two to three seconds. This was particularly noticeable after a pupa had been removed from and subsequently reintroduced to an ant nest. The pupa made no noise until it was "attended" by the ants. This phenomenon of pupal stridulation being immediately induced by contact with an attendant ant also occurs in other species of lycaenids, e.g. *Jalmenus evagoras* (Donovan) (RE, unpublished observation).

*A. wildei* pupa were also observed to oscillate. This oscillation consisted of a rapid dorso-ventral movement of the anterior end of the pupa. It was not determined if the pupal oscillation coincided with the sound production but they appeared independent. Interestingly, the frequency of the pupal oscillations also appeared to be the same as the frequency with which the host ants tapped on the substrate when alarmed.



## Discussion

Adults of *A. wildei* dramatically vary in size with wingspans of males and females ranging from 25-41 mm. The smallest adults may result from semi-mature larvae that had exhausted their available food supply or were left behind when a nest was abandoned by the ants, forcing the lycaenid larvae to pupate early. There is no evidence to indicate that larger *A. wildei* larvae migrate to new ant nests as is the case with another arboreal myrmecophagous lycaenid, *Liphyra brassolis* Westwood (Dodd 1902, J. Young pers. comm.). Smaller *A. wildei* larvae may be carried by *P. queenslandica* to a new site should the ant nest be destroyed or abandoned. However, larger larvae are very vulnerable and desiccate quickly outside the ant nest and may not be able to survive an extended journey.

Another measure that may be used by the butterfly to ensure an adequate food supply is cannibalism. In smaller ant nests or under adverse conditions *A. wildei* larvae seem to be able to regulate their numbers, and hence the available food supply, by this method. This hypothesis is supported by circumstantial evidence, including the fact that some smaller *P. queenslandica* ant nests were found to contain only one lycaenid larva yet had 2 or 3 recently eclosed eggs attached.

A very similar behaviour to the ant-assisted cuticle removal was recorded by Brewster (1913), where two *Polyrhachis ammon* (Fabricius) ants assisted the eclosion of a winged ant from its pupa. After being removed from the pupa the two ants continued to assist the imago "...one holding while the other pulled the wings clear of their sticky covering." Traniello (1982) and Hölldobler & Wilson (1990) also describe the care that ants bestow on their eggs, larvae and pupae including that of assisting the larval molt by licking the ecdysial skin free. Eclosion of an *A. wildei* adult in the presence of ants was not observed.

Pupal noise, produced by hammering on the substrate, has been recorded in six species of lycaenids (Downey 1966) and he suggested that the function was to frighten away small predators. However, DeVries (1990) suggested that lycaenid pupal noises mimic vibrations used by the ants for communication. It is possible that the pupal oscillation of *A. wildei* is a specialised form of communicative stridulation or alarm response similar to that of the *P. queenslandica* ants.

Pierce *et al.* (1987) deduced that significant extra numbers of new workers of *Iridomyrmex anceps* (Roger) can be produced by ants that are tending lycaenids and Nash (1989) was able to provide direct evidence that ant colonies exhibited significantly higher growth rates when they were able to tend lycaenid larvae. It would be reasonable to assume that larvae of *A. wildei* can similarly stimulate *P. queenslandica*. In addition, the NO of late instar larvae of *A. wildei* is proportionally larger than those observed on other myrmecophilous lycaenids, such as *J. evagoras* (Kitching 1983). If it is the

NO that produces the compounds that stimulate fecundity in the attendant ants, then this organ would be a very valuable asset to the *A. wildei* larva and may account for its increased size and prominence. Of course it is entirely possible that the exudates from the *A. wildei* organs are simply to 'bribe' the ants to prevent predation (Malicky 1970), while the larva consume the ants' brood. Whatever the purpose of the exudates, they are evidently very attractive to the ants. The exudates are also persistent, apparently remaining on the moulted *A. wildei* exuviae in sufficient amounts so that the ants are reluctant to eject these "foreign" objects from the nest.

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